SAWTOOTH OAK (*QUERCUS ACUTISSIMA*, FAGACEAE) IN NORTH AMERICA

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ABSTRACT

Sawtooth oak (*Quercus acutissima* Carruth.), native to eastern Asia, is widely planted in the eastern United States as a source of food for wildlife (especially turkeys) and as a landscape tree in developed areas. Spontaneous reproduction of sawtooth oak outside of cultivation has now been confirmed for Alabama, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Pennsylvania, and the District of Columbia. A complete description and an illustration are provided. Feral populations of sawtooth oak are mostly confined to open, often disturbed areas, and it spreads very slowly, apparently due to limited dispersal of the acorns. Planting of large stands of *Quercus acutissima* in natural areas or revegetating areas for wildlife food is likely to result in the establishment of this exotic species and its spread into adjacent habitats, but the use of sawtooth oak as a landscape tree in developed areas usually poses much less danger of escape.

RESUMEN

Quercus acutissima Carruth., nativo del este de Asia, está ampliamente cultivado en el este de los Estados Unidos como fuente de alimento para la fauna salvaje (especialmente pavos) y como árbol de paisaje en áreas desarrolladas. Su reproducción espontánea fuera de cultivo se ha confirmado ahora en Alabama, Louisiana, Maryland, Missouri, Mississippi, North Carolina, Pennsylvania, y el Distrito de Columbia. Se aporta una descripción completa y una ilustración. Las poblaciones silvestres de *Quercus acutissima* están mayormente confinadas a áreas abiertas alteradas, y se expande muy lentamente, debido aparentemente a la dispersión limitada de sus bellotas. El establecimiento de grandes plantaciones de *Quercus acutissima* en áreas naturales o áreas de revegetación para alimento de la fauna salvaje es probablemente la causa del establecimiento de esta especie exótica y su expansión en los hábitats adyacentes, pero el uso de *Quercus acutissima* como árbol de paisaje en áreas desarrolladas tiene mucho menos peligro de escape.

Sawtooth oak, *Quercus acutissima* Carruth., is a deciduous tree, native to open woodlands in eastern Asia, from northeastern India east to northern Vietnam and north to Japan and Korea (Huang et al. 1999). It was first introduced to the United States in 1862 (Rehder 1940), but it has only become common in cultivation in the past 50 years. Sawtooth oak has been widely planted as a source of food for wildlife (especially turkeys), because of its fast growth and early, heavy fruiting (Sullivan & Young 1961; Mercer 1969; Hopkins & Huntley 1979; Goelz & Carlson 1997; Stribling 1994). It has also has gained favor in recent years as a landscape tree because of its attractive form, rapid growth, and tolerance of difficult conditions (Spicer 1971; Francis & Johnson 1985; Gilbert & Henry 1988; Hensley et al. 1991; Tuttle 1995; Dirr 1998).

Some concern has been expressed about the use of *Q. acutissima* as wildlife food in the United States. Mercer (1969) said, "The sawtooth oak has aroused some apprehension.... Foresters wonder if it might become a "weed" tree. So far none of the plantings studied has increased in number of trees." Coblentz (1981) suggested that its high germination rate and high resistance to insect damage might indicate that *Q. acutissima* has the potential to spread widely in the southern United States. He noted that the potential for hybridization between sawtooth oak and native North American oaks had not been investigated. He also cited papers indicating that the acorns of sawtooth oak are less nutritious than acorns of native species, and less utilized by North American wildlife, and concluded that long-term management goals will be best met by improved management of diverse native hardwood communities rather than by planting sawtooth oak. Perhaps because of these concerns, many wildlife programs have returned to planting native oaks.

In recent years, *Quercus acutissima* has been reported to reproduce outside of cultivation in six states: Alabama (Younghance and Freeman 1996), Louisiana (Thomas and Allen 1998), Maryland (Terrell et al. 2000), Missouri (Yatskievych and Summers 1993), Mississippi (Kartesz 1999), and Pennsylvania (Rhoads and Klein 1993). The species is not mentioned in the treatment of *Quercus* L. for Flora of North America (Nixon et al. 1997). There are almost no published data on the ecology of sawtooth oak in North America, and the very brief description in Rhoads and Klein (1993) is the only description of the species in a North American identification manual.

Field and herbarium work in the eastern United States, and inquiry among active fieldworkers in the area, indicates that *Quercus acutissima* is escaping at sites across the eastern United States. Spontaneous reproduction of sawtooth oak outside of cultivation has now been confirmed for seven states and the District of Columbia. Since the species is becoming widespread and is being collected more frequently, it seems desirable to supply a full description of *Q. acutissima*, and a summary of its current range and habitat preferences in North America.

KEY TO SEPARATE *QUERCUS ACUTISSIMA* FROM NATIVE OAK GROUPS OF THE EASTERN UNITED STATES

1. Acorns maturing in the first fall after flowering (so all acorns in summer are ± the same size, and immature acorns are not present on the tree in winter). Tips of veins at leaf margin never projecting as bristles. Axils of major veins on leaf underside without conspicuous tufts of hairs. Bark light to medium gray, splitting into loose or more or less persistent ridges, plates, blocks or strips _____ White oaks (**Quercus** section **Quercus**)

1. Acorns maturing in the second fall after flowering (thus with large and small acorns on single twigs in summer, and immature acorns present in winter). Tips of veins at leaf margin almost always projecting as bristles 0.5–7 mm long. Axils of major veins on leaf underside usually with tufts of stalked 4–15-rayed hairs 0.3–0.5 mm high. Bark medium to dark gray, splitting into persistent ridges or blocks.

2. Scales of acorn cup lanceolate or strap-shaped, strongly recurved, 8–10 mm long. Leaf unlobed, its margin with 10–23 bristles on each side _____ **Quercus acutissima** (**Quercus** section **Cerris** Loudon)

2. Scales of acorn cup triangular, appressed, 1.5–5 mm long. Leaf not as above: either deeply lobed or with 0–3 bristles on each side _____ Black oaks (**Quercus** sect. **Lobatae** Loudon, sometimes called **Quercus** subgenus **Erythrobalanus** (Spach) Oerst.)

Quercus acutissima Carruth., J. Linn. Soc., Bot. 6:33. 1862. (**Fig. 1**). Sawtooth oak. Trees to 30 m tall. Bark medium to dark gray, divided into narrow persistent ridges. Twigs dark brown, puberulent with 1–5-rayed appressed (occasionally spreading) hairs, or glabrescent, 2–3 mm thick. Buds brown, 5–8 mm long, pubescent (at least the upper half), scales long-ciliate. Petioles 10–39 mm long. Leaf blade lance-oblong to lanceolate or oblanceolate, 11–21 cm long, 3–6 cm wide, base rounded or truncate; secondary veins each (except the basalmost) reaching the margin at the tip of a tooth and ending in a bristle, teeth 10–23 on each side of the blade, well-developed teeth obtuse to acuminate, each tooth ending in a single bristle 2–5 mm long. Upper surface of blade shiny, with scattered inconspicuous simple (rarely 2–4-rayed) hairs; lower surface green, the blade with inconspicuous unbranched appressed hairs, the veins with spreading simple hairs, vein axils with small tufts of ca 4-rayed stalked fasciculate hairs. Calyx of female flower fused to the ovary. Anthers retuse. Styles linear, their tips not broadened. Nuts ripe the second autumn after flowering. Peduncle 0–2 mm long. Acorn cup hemispherical, 14–15 mm long, 18–25 mm wide, covering 0.3–0.5 of the nut, its inner surface smooth, hairy. Cup scales narrowly lanceolate or strap-shaped from a short triangular base, 8–10 mm long, weakly costate, free from cup for their whole length and strongly recurved, the scales at the margin of the cup longer but otherwise not differentiated. Nut ovoid to ovoid-cylindrical, 15–20 mm long, 13–17 mm wide. Inner surface of the shell densely pubescent, abortive ovules near the base, seed coat adhering to the fruit wall.

Flowering in April. Native to Asia, from Korea and Japan south to Vietnam and west to northeastern India.

Representative specimens examined: **ALABAMA. Bibb Co.:** 8 mi S of Centerville along levee dirt road, off of county road 219, 32° 52′ 30″ N, 87° 00′ 00″ W, elev. 465 ft, *S.T. Smith* s.n., 10 Jul 1999 (AUA). **DISTRICT OF COLUMBIA:** Spontaneous small tree 5 m tall, trunk 6.5 cm thick, open grassy (partly cleared) margin of *Quercus* spp. woodland, north side of Beechwood Road near its intersection with Ellipse Road, U.S. National Arboretum, *A.T. Whittemore 00-014*, 29 Aug 2000 (CAS, NA, MOR, MU, UNC, US). **LOUISIANA. Winn Parish:** along paved road leading to Blewer's Pond at Bienville Parish Line, north of LA 126 and NE of Roadheimer, sect. 6, T13N R5W, *K.H. Kessler 1864*, 20 Sep 1981 (AUA). **MARYLAND. Prince George's Co.:** scattered adult trees with frequent saplings, open second-growth *Quercus* woodland, edge of Beltsville Agricultural Research Center along I-495 near the Cherry Hill Rd. overpass, north side of College Park, *A.T. Whittemore 01-058*, 28 Nov 2001. (NA). **MISSISSIPPI. Lafayette Co.:** open area along Forest Service road, Tallahatchie Experimental Forest rd. T-3, N of County Road 244, Holly Springs National Forest, UTM: 2 76 238E, 38 21 127N (GPS); *L.M. McCook & M. Hodson 2180*, 26 Jun 2000 (MISS, NA). **MISSOURI. Franklin Co.:** *Quercus–Carya* woodland below

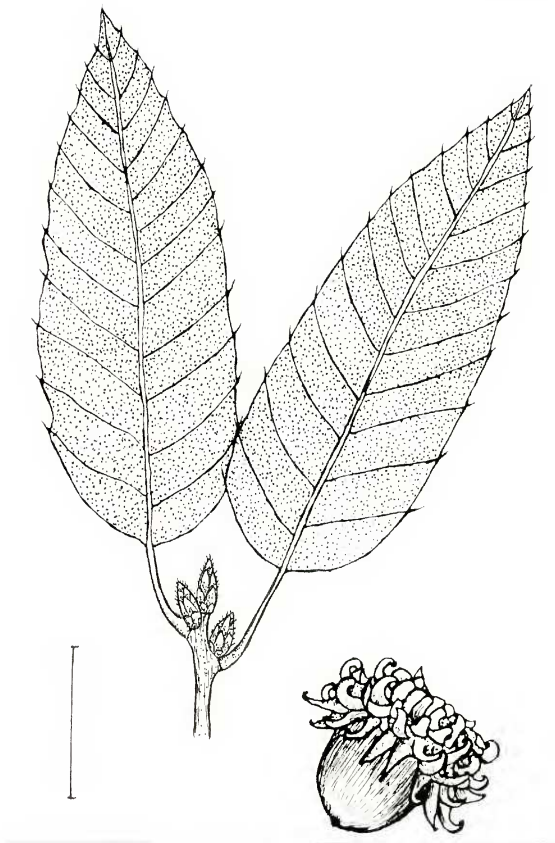

FIG. 1. *Quercus acutissima* foliage and acorn. Scale bar = 3 cm.

the nursery, next to Old Gray's Summit Road, Shaw Nature Reserve, S of Gray's Summit, *A.T. Whittemore 01-029* 15 Oct 2001 (NA). **NORTH CAROLINA. Orange Co.:** disturbed area along drive to Craige Dormitory, UNC Campus, Chapel Hill, *Emily W. Wood 863*, 2 Apr 1974 (MO). **PENNSYLVANIA. Lehigh Co.:** escape in fallow field 2 mi NW of Newside, *R.L. Schaeffer, Jr. 49540*, 26 Jul 1955 (PH).

These specimens represent areas where the species is definitely reproducing outside of cultivation. Specimens of planted trees have been seen from most parts of the eastern United States.

Quercus acutissima is easily distinguished from all native North American oaks. No native North American oak has unlobed leaves with numerous marginal bristles, and no native North American oak has the scales of the acorn cup long and reflexed. Sterile specimens of *Castanea* spp. are sometimes confused with *Q. acutissima*. Species of *Castanea* almost always have the leaves and buds in two regular ranks and not crowded at the stem apex. The sole exception to this is *Castanea dentata* (Marshall) Borkhausen, in which the leaves and buds of lateral stems are two-ranked and not crowded apically, as in other *Castanea* spp., while those of the leading stems are arranged in several irregular ranks and ± crowded at the stem apex, similar to stems of *Quercus*. Fertile material of *Castanea* is easily distinguished by characters of the inflorescence (erect and rigid in *Castanea*, pendent and lax in *Quercus*) and fruit (the nut in *Castanea* is completely enclosed in a valvate husk that is covered with long spines, while in *Quercus* the nut is in an unlobed scaly cup). The only exotic oak that resembles *Q. acutissima* is *Q. variabilis* Blume, another Asian species that is rarely cultivated in North America. *Quercus variabilis* is very similar to *Q. acutissima*, differing only in having glabrous twigs, dense stellate pubescence on the underside of the leaf blade, and bark that is usually somewhat corky. A third species sometimes recognized from Asia, *Q. chenii* Nakai, is probably a synonym of *Q. acutissima*.

Quercus acutissima reproduces spontaneously in grassland, open margins of deciduous woodlands, and other open disturbed areas. Sawtooth oak is especially prolific in mowed meadows. Mowing keeps the seedlings small, but does not seem to harm them otherwise. Seedlings are found only in close proximity to adult trees. Careful searches at several sites in Missouri, Maryland and the District of Columbia showed that almost all seedlings and saplings grow within 20 m of an adult tree, and none was found more than 100 m from an adult, suggesting that spread of the tree is severely limited by short seed dispersal.

As with other introduced species (i.e. *Lonicera maackii* (Rupr.) Maxim., Luken & Thieret 1995), sawtooth oak was slow to appear in the North American floristic literature. The first literature report of sawtooth oak as an escape in North America (Rhoads & Klein 1993) came 38 years after the first herbarium collection documenting it (*Schaeffer 49540*, 26 Jul 1955; see specimens examined above), and it is still not treated in many recent floras. This may have de-

layed recognition of the plant in some areas, since collectors who encounter it may not be able to key it out or find descriptions of it.

Quercus acutissima is a member of *Quercus* sect. *Cerris* Loudon, a group of about forty species native to Eurasia and North Africa. In the past, this group has sometimes been included in sect. *Quercus* (the white oaks; Nixon 1993), but it is now clear that the white oaks and section *Cerris* are not closely related (Manos et al. 1999, 2001). Hybridization between *Q. acutissima* and native oaks, cited as a potential area of concern by Coblentz (1981), is not likely to be a problem. Cottam et al. (1982) attempted numerous crosses between species of sect. *Cerris* and various native North American oak species, with little success. They found that it is very difficult to obtain hybrids between species from different sections of the genus, even when all competing pollen is strictly excluded by bagging and emasculation of the bagged branches. *Quercus acutissima* was not one of the species they used, but they made extensive use of *Q. variabilis*, which is a very close relative based on numerous morphological (Huang et al. 1999) and molecular (Manos et al. 2001) characters. Cottam et al. (1982) attempted pollinations between *Q. variabilis* and sixteen species of white and black oaks, and they were unable to obtain a single hybrid from any of these pollinations.

It is difficult to predict the long-term performance of sawtooth oak in the vegetation of eastern North America, since the decades that have passed since large-scale planting of the species in North America began are less than a full generation for the species. Even so, because sawtooth oak seedlings are able to establish themselves, mature, and set seed in reasonably natural habitats, *Quercus acutissima* should be considered naturalized, in the sense of Nesom (2000). Concerns about planting large stands of *Quercus acutissima* in natural areas seem to be well founded. In such sites, sawtooth oak can be expected to reproduce and spread slowly into adjacent open fields and woodland margins. The use of sawtooth oak as a landscape tree in developed areas usually poses much less danger of escape, primarily because of the short seed dispersal distances of the species. However, trees planted close to disturbed grassland and open woodland may be expected to invade these sites. Furthermore, the heavy acorn drop in autumn and the frequent seedlings in garden beds are undesirable characteristics in a landscape tree and cultivars with lower seed set would certainly be desirable.

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REFERENCES

Coblentz, B.E. 1981. Possible dangers of introducing sawtooth oak. Wildl. Soc. Bull. 9: 136–138.

Cottam, W.P., J.M. Tucker, and F.S. Santamour, Jr. 1982. Oak hybridization at the University of Utah. State Arboretum of Utah Publ. No. 1. pp. i–xiv, 1–82.

Dirr, M.A. 1998. Manual of woody landscape plants. ed. 5. Stipes Publishing, Champaign, IL.

Francis, J.K. and R.L. Johnson. 1985. Direct-seeded sawtooth oaks (*Quercus acutissima* Carruth.) show rapid growth on diverse sites. Tree Pl. Notes–U. S. Forest Service 36:3–5.

Gilbert, C.F. and D.S. Henry. 1988. *Quercus acutissima* 'Gobbler'. Amer. Nurseryman 168(3):122.

Goelz, J.C.G. and D.W. Carlson. 1997. Growth and seed production of sawtooth oak (*Quercus acutissima*) 22 years after direct seeding. Research note SO-386. USDA-Forest Service Southern Research Station, Stonesville MS. Pp. 1–7.

Hensley, D.L., S.C. Wiest, C.E. Long, J.C. Pair and F.D. Gibbons. 1991. Evaluation of ten landscape trees for the midwest. J. Environ. Hort. 9:149–155.

Hopkins, C.R. and J.C. Huntley. 1979. Establishment of sawtooth oak as a mast source for wildlife. Wildl. Soc. Bull. 7:253–258.

Huang, C., Y. Zhang and B. Bartholomew. 1999. Fagaceae. In: Z.-Y. Wu and P.H. Raven, eds. Flora of China, vol. 4. Science Press, Beijing. Pp. 314–400.

Kartesz, J.T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. First Edition. In: Kartesz, J.T., and C.A. Meacham. Synthesis of the North American flora. CD-ROM, Version 1.0. North Carolina Botanical Garden, Chapel Hill, NC.

Luken, J.O. and J.W. Thieret. 1995. Amur honeysuckle (*Lonicera maackii*; Caprifoliaceae): its ascent, decline, and fall. Sida 16:479–503.

Manos, P.S., J.J. Doyle and K.C. Nixon. 1999. Phylogeny, biogeography, and processes of differentiation in *Quercus* subgenus *Quercus* (Fagaceae). Molec. Phylogenetics and Evol. 12:333–349.

Manos, P.S., Z.-K. Zhou and C.H. Cannon. 2001. Systematics of Fagaceae: phylogenetic tests of reproductive trait evolution. International journal of plant sciences. 162:1361–1379.

Mercer, J., Jr. 1969. Sawtooth oak holds promise as wildlife plant for Southeast. Soil Conservation 34:178.

Nesom, G.L. 2000. Which non-native plants are included in floristic accounts? Sida 19: 189–193.

Nixon, K. 1993. Infrageneric classification of *Quercus* (Fagaceae) and typification of sectional names. Ann. Sci. For. 50 (suppl. 1):25s–34s.

Nixon, K.C., R.J. Jensen, P.S. Manos and C.H. Muller. 1997. *Quercus*. In: Flora of North America Editorial Committee (eds.), Flora of North America Vol. 3. Oxford University Press, New York. Pp. 445–506.

Reheder, A. 1940. Manual of cultivated trees and shrubs hardy in North America, exclusive of the subtropical and warmer temperate regions. Ed. 2. New York.

Rhoads, A.F. and W.M. Klein Jr. 1993. The vascular flora of Pennsylvania: Annotated checklist and atlas. Amer. Philos. Soc., Philadelphia.

Spicer, G. 1971. Trees tough enough for the city. Amer. Nurseryman 133(10):7–8.

Stribling, H.L. 1994. Planting sawtooth oak for wildlife. Circular ANR-851. Alabama Cooperative Extension Service, Auburn. Pp. 1–2.

Sullivan, E.G. and W.C. Young. 1961. An exotic oak, *Quercus acutissima*, for wildlife food planting. In: E. Conner Jr., ed. Proceedings of the fifteenth annual conference of the Southeast Association of Game and Fish Commissions. Southeast Association of Game and Fish Commissions, Nashville, TN. Pp. 136–141.

Tuttle, G.A. 1995. Tree of the month: *Quercus acutissima*, sawtooth oak. Arbor Age 15(1):28.

Yatskievych, G. and B. Summers. 1993. Studies in the flora of Missouri, IV. Missouriensis 14: 27–42.

Younghance, S.L. and J.D. Freeman. 1996. Annotated checklist of trees and shrubs of Alabama. Sida 17:367–384.